

# PATENT SPECIFICATION

(11) 1 433 875

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- (21) Application No. 38547/72 (22) Filed 18 Aug., 1972  
 (23) Complete Specification filed 7 Nov. 1973  
 (44) Complete Specification published 28 April 1976  
 (51) INT CL<sup>7</sup> G01F 13/00; F02M 37/04  
 (52) Index at acceptance  
 F1B 2J15B2 2J15D 2M4 2MSA 2M5C

(19)



## (54) IMPROVEMENTS IN OR RELATING TO LIQUID SUPPLY AND MEASURING SYSTEMS

- (71) I, BRIAN LIONEL HUNT BISHOP, a British Subject of 43a Curbridge Road, Witney, Oxfordshire, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed to be particularly described in and by the following statement:—
- This invention relates to improvements in or relating to recirculatory liquid supply systems. The invention is especially concerned with a method of supplying fuel to internal combustion engines but may find application in other liquid supply systems such as mobile bulk supply tankers or stationary installations.
- Certain fuel supply systems currently used for internal combustion engines are recirculatory including a fuel supply duct, which sometimes incorporates a flowmeter, and a return pipe or duct, or a plurality thereof, through which unused fuel is returned from some part, or parts, of the engine to the fuel storage reservoir. These systems present difficulties if it is important to be able to obtain a substantially accurate measurement of the quantity of fuel consumed by the engine in a particular period since measurement recorded by the flowmeter is in error by the amount of fuel returned to the reservoir. Moreover, the problem cannot be readily overcome by utilising a second flowmeter for measuring the quantity of fuel returned as such measurement is made difficult in certain cases by the presence of vapours or gases, such as air, together with liquid fuel in the
- It is an object of the present invention to overcome the aforementioned problem and to enable the total quantity of liquid supplied from a recirculatory liquid supply system to be measured more accurately than hitherto.
- According to one aspect of the present invention I provide in a recirculatory liquid supply system including a main and a subsidiary storage reservoir a method of recirculating unused liquid which permits a substantially accurate measurement of total liquid supplied from the recirculatory liquid supply system to be made, said method comprising the steps of:
- supplying liquid from the main storage reservoir through a supply duct to discharge means;
  - measuring the quantity of liquid so supplied by means of a flow meter in the supply duct;
  - returning any unused liquid from the discharge means to the subsidiary storage reservoir through a return duct;
  - returning liquid in the subsidiary reservoir to the supply duct downstream of the flowmeter through a subsidiary return duct;
  - and controlling such return of unused liquid through the subsidiary return duct so that a quantity of liquid always remains in the subsidiary reservoir.
- By discharge means I mean any device, apparatus, or mechanism positioned on the downstream side of the flow meter from which unused liquid is recirculated.
- Preferably, the return of liquid from the subsidiary storage reservoir to the supply

### ERRATUM

SPECIFICATION NO 1433875

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 17 September 1976

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## (54) IMPROVEMENTS IN OR RELATING TO LIQUID SUPPLY AND MEASURING SYSTEMS

(71) I, BRIAN LIONEL HUNT BISHOP, a British Subject of 43a Curbridge Road, Witney, Oxfordshire, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed to be particularly described in and by the following statement:—

This invention relates to improvements in or relating to recirculatory liquid supply systems. The invention is especially concerned with a method of supplying fuel to internal combustion engines but may find application in other liquid supply systems such as mobile bulk supply tankers or stationary installations.

Certain fuel supply systems currently used for internal combustion engines are recirculatory including a fuel supply duct, which sometimes incorporates a flowmeter, and a return pipe or duct, or a plurality thereof, through which unused fuel is returned from some part, or parts, of the engine to the fuel storage reservoir. These systems present difficulties if it is important to be able to obtain a substantially accurate measurement of the quantity of fuel consumed by the engine in a particular period since measurement recorded by the flowmeter is in error by the amount of fuel returned to the reservoir. Moreover, the problem cannot be readily overcome by utilising a second flowmeter for measuring the quantity of fuel returned as such measurement is made difficult in certain cases by the presence of vapours or gases, such as air, together with liquid fuel in the return pipe or duct.

Recirculation of liquid in a liquid supply system is sometimes necessary for a variety of reasons, for example in order to lubricate or cool a part of the discharge mechanism, or to avoid a pressure build up in the system if a filter or duct should become blocked, or a relief valve fails to seat properly. Once the liquid has passed through the flowmeter, should any be returned to the storage tank the meter reading is rendered inaccurate.

It is an object of the present invention to overcome the aforementioned problem and to enable the total quantity of liquid supplied from a recirculatory liquid supply system to be measured more accurately than hitherto.

According to one aspect of the present invention I provide in a recirculatory liquid supply system including a main and a subsidiary storage reservoir a method of recirculating unused liquid which permits a substantially accurate measurement of total liquid supplied from the recirculatory liquid supply system to be made, said method comprising the steps of:

supplying liquid from the main storage reservoir through a supply duct to discharge means;

measuring the quantity of liquid so supplied by means of a flow meter in the supply duct;

returning any unused liquid from the discharge means to the subsidiary storage reservoir through a return duct;

returning liquid in the subsidiary reservoir to the supply duct downstream of the flowmeter through a subsidiary return duct;

and controlling such return of unused liquid through the subsidiary return duct so that a quantity of liquid always remains in the subsidiary reservoir.

By discharge means I mean any device, apparatus, or mechanism positioned on the downstream side of the flow meter from which unused liquid is recirculated.

Preferably, the return of liquid from the subsidiary storage reservoir to the supply duct is controlled by flow control means which not only controls the rate of the flow so that it is related to the quantity of liquid in the subsidiary reservoir but is adjusted to stop such flow when the level of liquid in the subsidiary storage reservoir falls to a predetermined datum.

The subsidiary storage reservoir is preferably positioned at a higher level than the supply duct so that liquid can be fed into the supply duct under gravity. It is also prefer-

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able that the subsidiary reservoir should be at a higher level than the main reservoir in order to eliminate the possibility of liquid siphoning from the main reservoir into the subsidiary reservoir. The flowmeter may serve as a non-return device and prevent liquid from returning to the main reservoir from the subsidiary reservoir but an additional non-return device such as a non-return valve may be incorporated in the supply duct if required.

Liquid may be supplied to the discharge means from either the main or the subsidiary reservoir or both simultaneously.

The method may include the step of measuring the amount of liquid remaining in the subsidiary storage reservoir before and after operation of the system and either adding the difference in quantity to the total recorded by the flowmeter or subtracting same therefrom.

According to another aspect of the invention apparatus is provided for carrying out the method as hereinbefore defined.

Such apparatus comprises a main and a subsidiary liquid storage reservoir, a pump for pumping liquid from the main storage reservoir to a discharge means through a supply duct, a flowmeter in the supply duct for measuring the quantity of liquid pumped from the main storage reservoir to the discharge means, the subsidiary storage reservoir being connected for receiving unused liquid returned from the discharge means, a subsidiary return duct for returning liquid from the subsidiary reservoir to the supply duct downstream of the flowmeter, and flow control means for controlling the flow of liquid from the subsidiary storage reservoir to the supply duct.

Conveniently, the flow control means comprises a float operated flow control and shut off valve incorporated in the subsidiary reservoir outlet.

The valve may comprise a tapered portion adapted to throttle the outlet progressively as, in use, the level of liquid in the subsidiary reservoir falls and to open the outlet progressively as the liquid level therein rises.

The valve may be spring biased to the closed position and/or it may be actuated by a spring toggle or similar over-centre lever mechanism which provides a positive closing and a positive opening action.

The valve may be of the rotary type, being adapted to be actuated by a linkage mechanism for converting reciprocating movement of the float into rotary movement of the valve.

The subsidiary reservoir may be vented directly to atmosphere or it may be vented into the main reservoir. The subsidiary reservoir may be provided with visual liquid level indicating means for measuring its contents which could take the form of a dip

stick, or a calibrated sight glass, or a transparent or translucent tank which has calibrations marked thereon or a part of the tank being transparent or translucent and being so marked.

A preferred embodiment of the invention as applied to a vehicle diesel engine fuel supply system will now be described by way of example only with reference to the accompanying drawings in which:—

Figure 1 is a schematic diagram of a fuel supply system and

Figure 2 is a vertical cross-section through a typical oil fuel injector for a diesel engine.

With reference to Figure 1 of the drawings there is depicted a main storage reservoir 2 for diesel oil fuel which is connected by a supply pipe to a diesel engine 7. The supply pipe comprises three sections 1, 4 and 5. The first section 1 extends vertically from a point adjacent to the bottom of the main reservoir 2 outwardly through the top of the reservoir and connects to the inlet of a positive displacement flowmeter 3. A non-return valve 16 is incorporated in the pipe between the reservoir and the flowmeter. A second section 4 connects with the flowmeter outlet and with one arm of a 'T' shaped connector 15, and a third section 5 connects with the opposed arm of the connector 15 and the inlet of a fuel pump 6 mounted at the side of the engine 7.

Mounted directly above the connector 15, and at a higher level than the main storage reservoir 2, there is a subsidiary fuel storage reservoir 9. The subsidiary reservoir 9 is connected to a spill manifold 17 at the side of the engine 7 by means of a pipe 8 which extends between the manifold 17 and the upper part of the reservoir 9. The manifold 17 collects recirculated fuel flowing from a number of leak-off pipes 18 connected to fuel injectors 19. The number of pipes 18 corresponds to the number of cylinders in the engine 7.

The subsidiary reservoir 9 is provided with an outlet 14 which extends through the bottom of the reservoir and is connected by a pipe 22 to the vertically extending neck of the 'T' connector 15. The outlet 14 is cylindrical and protrudes above the bottom of the reservoir so that it serves as a stack pipe. The top free edge of the outlet 14 is formed with a flange 23 which provides an annular seat for a flow control and shut-off valve 13. The valve 13 is actuated by a float 12 and is analogous to the well known cistern ball valve mechanism. The valve 13 has a cone shaped lower portion 24 which serves to throttle the outlet 14 as the level of fuel in the reservoir falls. It is provided with an annular washer of resilient material which is retained in a groove around the base of the cone 24. The washer co-operates with the seat 23 and seals the outlet when the fuel

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level has fallen below a predetermined datum. An upper body portion of the valve 13 is pivotally connected by a pivot pin 20 to an intermediate part of the float arm 21 so that the valve depends vertically therefrom and that end of the arm 21 opposite the float 12 is pivotally connected to a yoke 25 rigidly mounted on the side of the reservoir 9. Thus as the level of fuel in the subsidiary reservoir rises or falls the valve 13 will swing away from or toward the seat 23. It will be appreciated that the valve arrangement is shown schematically and in practice incorporates a slide or guide extending vertically above the outlet. A spring may be incorporated in the slide to bias the valve 13 toward the closed position and prevent any tendency for the valve to bounce on its seat 23 due to surging of the fuel as the vehicle is in motion on a bumpy road. The subsidiary reservoir 9 is not provided with a filler cap so that it cannot be filled with fuel inadvertently; it is however provided with a vent pipe 10 venting directly to atmosphere. Alternatively, the vent pipe 10 may be connected to the top of the main reservoir 2, as shown by the dotted outline of a pipe 11. The subsidiary reservoir 9 may also be provided with baffles to reduce surging of the fuel.

With reference to Figure 2 which shows a known type of diesel fuel injector it will be appreciated that fuel under pressure from the pump 6 enters the injector 19 by the inlet 26 and is directed to an annulus 29 around the seat of a nozzle valve 27. The nozzle valve 27 is normally held on its seating by a spring biased spindle 28, the loading of which is adjustable. When a predetermined pressure is reached the valve 27 is lifted off its seating and fuel is injected to the engine through the nozzle 30. Any leakage of fuel at the end of the injection, which is characteristic of such injectors, passes up the bores accommodating the valve 27 and spindle 28 and accumulates in the chamber 31 surrounding the valve spring. This fuel is fed to the leak-off pipe 18 and returns to the subsidiary reservoir 9 through the pipe 8. Fuel may also be fed to the reservoir 9 from other parts of the engine through the spill manifold 17, for example from a fuel filter or pressure relief valve.

In operation of the system, when the vehicle engine is running it is supplied with fuel under pressure by the fuel pump 6 which draws fuel from either or both of the reservoirs 2 and 9, the flowmeter 3 measuring only the quantity of fuel taken from the main reservoir 2. Surplus fuel flowing back from the engine 7 into the subsidiary reservoir 9 causes the level in that reservoir to rise, whereupon the float 12 rises and the annular opening around the cone 24 becomes progressively larger so allowing more

fuel to pass to the junction 15 where, as the junction 15 is upstream of the pump 6, it is entrained into the supply pipe 5 and returns to the suction side of the pump 6. Any gases or vapours entering the reservoir 9 with fuel returned from the engine are vented through the pipe 10. When the level of fuel in the subsidiary reservoir falls below the predetermined datum the valve 13 closes completely. The valve mechanism is adjusted so that closure occurs whilst the level of fuel is still above the valve seat 23. Thus only liquid fuel can pass into the outlet 14 and supply pipe 5.

During operation of the system air will enter or leave the reservoir 9 through the vent pipe 10, either directly to or from the atmosphere or to or from the air space above the fuel in the main reservoir 2 through the pipe 11, if this is incorporated. In the event of the valve 13 failing in the closed or nearly closed position, the pipe 11 would prevent loss of fuel from the system by returning fuel from the subsidiary reservoir 9 to the main reservoir 2, but such a circumstance would render incorrect the readings of the flowmeter 2.

When the engine is not running a quantity of fuel will remain in the subsidiary reservoir 9, and in the event that the valve 13 is not on its seat 23, it is prevented from draining back into the main reservoir 2 by the action of the non-return valve 16, this obviates the necessity for frequent priming of the system. In order to obtain an accurate measurement of engine fuel consumption measurements of the quantity of fuel remaining in the reservoir 9 at the beginning and at the end of a journey are read on a sight glass (not shown) on the side of the reservoir and after a simple calculation to find the difference in quantity before and after operation of the system this difference in quantity is either added to or subtracted from that indicated on the flowmeter.

It will be realised that many modified forms of flow control mechanism for the reservoir 9 are possible without departing from the scope of the invention. For example the mechanism could comprise a rotary type valve actuated directly by the arm 21 of the float 12 and a mechanism for converting reciprocating movement into a rotary movement. Separately, or in addition, to a spring or springs for holding the valve onto its seat, a system of levers, such as spring biased toggle levers, may be provided for actuating the valve, the geometry of which is such that the valve snaps closed or open after passing a predetermined closure point or opening point, thus giving more positive valve closure and opening and hysteresis in valve operation.

In another modification the outlet for the reservoir 9 is on the side of the reservoir and

the valve moves horizontally in the manner of the well known float operated cistern valve but is arranged to close the outlet as the level of fuel falls.

- 5 Means for readily adjusting the operative relationship between valve and its seat may also be incorporated so that the point of closure and hence the level of fuel remaining in reservoir 9 may also be adjusted.

#### WHAT I CLAIM IS:—

1. In a recirculatory liquid supply system including a main and a subsidiary storage reservoir a method of recirculating unused liquid which permits a substantially accurate measurement of total liquid supplied from the recirculatory liquid supply system to be made, said method comprising the steps of:

supplying liquid from the main storage reservoir through a supply duct to discharge means;

measuring the quantity of liquid so supplied by means of a flowmeter in the supply duct;

25 returning any unused liquid from the discharge means to the subsidiary storage reservoir through a return duct;

returning liquid in the subsidiary reservoir to the supply duct downstream of the flowmeter through a subsidiary return duct;

30 and controlling such return of unused liquid through the subsidiary return duct so that a quantity of liquid always remains in the subsidiary reservoir.

2. A method as claimed in claim 1 in which the flow control means controls the rate of flow through the subsidiary return duct so that it is related to the quantity of liquid in the subsidiary reservoir.

3. A method as claimed in claim 1 or claim 2 in which the flow control means is adjusted to stop the flow when the level of liquid in the subsidiary storage reservoir falls to a predetermined datum.

4. A method as claimed in any preceding claim in which the subsidiary reservoir is at a higher level than the supply duct and liquid is returned to the supply duct under gravity.

5. A method as claimed in any preceding claim in which the subsidiary reservoir is at a higher level than the main reservoir.

6. A method as claimed in any preceding claim in which liquid is supplied to the discharge means from either the main or the subsidiary reservoir or both simultaneously.

7. A method as claimed in any preceding claim including the step of measuring the amount of liquid in the subsidiary reservoir before and after operation of the system and either adding the difference in quantity to the total recorded by the flowmeter or subtracting same therefrom.

8. In a recirculatory liquid supply system a

method of recirculating unused liquid substantially as hereinbefore described with reference to the accompanying drawings.

9. Apparatus for carrying out the method as claimed in any preceding claim comprising a main and a subsidiary liquid storage reservoir, a pump for pumping liquid from the main storage reservoir to a discharge means through a supply duct, a flowmeter in the supply duct for measuring the quantity of liquid pumped from the main storage reservoir to the discharge means, the subsidiary storage reservoir being connected for receiving unused liquid returned from the discharge means, a subsidiary return duct for returning liquid from the subsidiary reservoir to the supply duct downstream of the flowmeter and flow control means for controlling the flow of liquid from the subsidiary storage reservoir to the supply duct.

10. Apparatus as claimed in claim 9 in which the flowmeter is of the positive displacement type.

11. Apparatus as claimed in claim 9 or claim 10 including a non-return device for preventing liquid returning to the main storage reservoir through the supply duct.

12. Apparatus as claimed in any of claims 9 to 11 in which the flow control means comprises a float operated flow control and shut-off valve incorporated in the outlet of the subsidiary reservoir.

13. Apparatus as claimed in claim 12 in which the valve is actuated by a spring toggle mechanism providing positive opening and closure of the valve.

14. Apparatus as claimed in Claim 12 or Claim 13 in which the valve comprises a tapered portion adapted to throttle the outlet progressively as in use the liquid level in the subsidiary reservoir falls and to open the outlet progressively as the liquid level therein rises.

15. Apparatus as claimed in any of Claims 12 to 14 in which the outlet comprises a stack pipe extending above the bottom of the reservoir, an annular valve seat being provided at or adjacent to the upper end of the stack pipe for co-operation with the valve.

16. Apparatus as claimed in any of Claims 9 to 15 in which the subsidiary reservoir is provided with visual liquid level indicating means.

17. Apparatus as claimed in Claim 16 in which the liquid level indicating means comprises a sight glass.

18. Apparatus as claimed in Claim 16 in which the liquid level indicating means comprises a partly or wholly transparent or a partly or wholly translucent reservoir having quantitative calibrations marked thereon.

19. Apparatus as claimed in Claim 12 or

13 or any of Claims 16 to 18 in which the float operated valve comprises a rotary valve the valve being adapted to be actuated by a linkage mechanism for converting  
5 reciprocating movement of the float into rotary movement of the valve.

20. Apparatus as claimed in any of Claims 9 to 19 in which the discharge means comprises a fuel injector device of an internal combustion engine, the injector device  
10 incorporating a leak-off pipe through which

unused fuel is recirculated.

21. Apparatus claimed in any claims 9 to 20 and substantially as hereinbefore described with reference to and as shown in  
15 the accompanying drawings.

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Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1976.  
Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from  
which copies may be obtained.

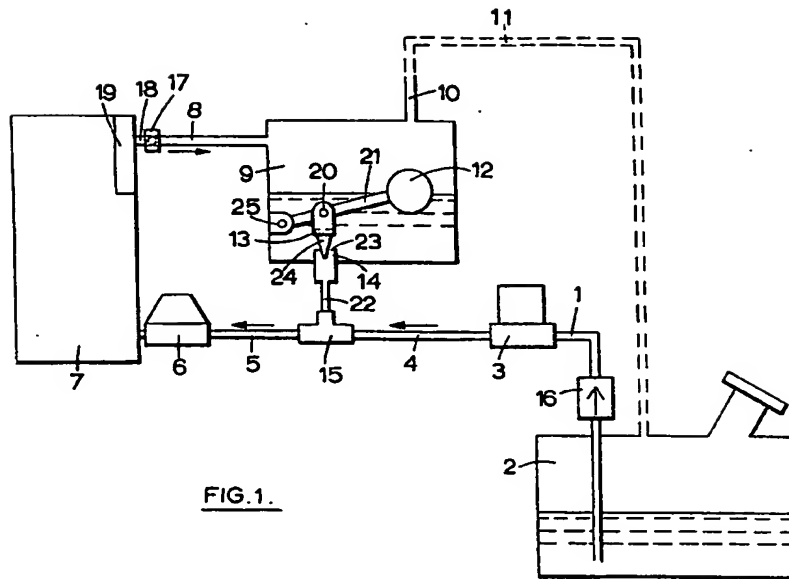


FIG. 1.

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